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(54) Abstract Title

Method and apparatus of particle transfer in multi-stage particle separators

(57) An improved two-stage separator uses reusable containers for collecting particles separated by each separation stage. The reusable containers are constructed such that a user empties both reusable containers by the actions required to empty just one of the reusable containers.

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Method and apparatus of particle transfer in multi-stage particle separators

Claims of corresponding document: WO0195780

I CLAIM: 1. A vacuum cleaner comprising: (a) a cleaner head having a dirty air inlet; and, (b) a casing having a filtration member, the filtration member having an inlet in fluid flow communication with the dirty air inlet and an outlet in fluid flow communication with a source of suction, the filtration member comprising at least one upstream particle separator having an associated upstream particle collector and at least one downstream particle separator having an associated downstream particle collector, the particle collectors are configured such that the downstream particle collector is emptied by transferring its contents into the upstream particle collector.

2. The vacuum cleaner of claim 1 wherein at least a portion of the upstream particle separator is removable from the casing and the downstream particle collector is emptied into the upstream particle collector when the portion of the upstream particle collector is removed from the casing.

3. The vacuum cleaner of claim 1 further comprising a particle transfer member positioned between one of the particle separation members and its associated particle collector whereby particles separated by the said particle separation member are conveyed to said particle collector.

4. The vacuum cleaner of claim 3 wherein at least a portion of the particle transfer member is angled downwardly whereby particles travel to said particle collector at least partially under the influence of gravity.

5. The vacuum cleaner of claim 1 wherein the downstream particle separation member is chosen from the group of a cyclone, a Prandtl layer turbine and an electrostatic filter.

6. The vacuum cleaner of claim 1 wherein the downstream particle collector is positioned in the upstream particle separation member.

7. The vacuum cleaner of claim 2 wherein the downstream particle collector is pivotally mounted above the upstream particle collector.

8. The vacuum cleaner of claim 2 wherein the downstream particle collector has side walls and a bottom that is mounted for movement between a closed position and an open position and the bottom moves to the open position as the upstream particle collector is prepared for emptying.

9. The vacuum cleaner of claim 8 wherein the bottom is maintained in the closed position by interaction between the bottom and a member positioned on a portion of the vacuum cleaner that is not removed with the upstream particle collector.

10. The vacuum cleaner of claim 2 wherein the downstream particle collector is disposed adjacent the upstream particle separation member.

11. A separator for separating entrained particles from a fluid flow, the separator comprising: (a) a first particle separation member; (b) a reusable particle collector disposed beneath the particle separation member, the particle collector having a moveable member movably mounted between a closed position and an open position; and, (c) a particle receiving chamber disposed beneath the particle collector, wherein when the moveable member moves from its closed position to its open position, particles collected in the particle collector are substantially transferred to the particle receiving chamber.

12. The separator of claim 11 wherein the first particle separation member is chosen from the group of a cyclone, a Prandtl layer turbine and an electrostatic filter.

13. The separator of claim 11 further comprising a second particle separation member, wherein the particle receiving chamber receives particles separated from the fluid flow by the second particle separation member.

14. The separator of claim 13 wherein the second particle separation member has an outer container and a first assembly positioned in the outer container, the reusable particle collector has side walls and the moveable member comprises a lower portion and the side walls are removable with the first assembly from the outer container.

15. The separator of claim 13 wherein the second particle separation member has an outer container and a first assembly positioned in the outer container, the reusable particle collector has side walls mounted on the removable assembly, the moveable member comprises a lower portion and the lower portion is mounted on the outer container for rotational movement with respect to the side walls.

16. The separator of claim 13 wherein the second particle separation member has an outer container and a first assembly positioned in the outer container, the reusable particle collector has side walls and the moveable member comprises a lower portion pivotally mounted with respect to the side walls and lockable in the closed position by interaction with a member provided on the outer container.

17. A separator comprising: (a) an inlet in fluid flow communication with a source of fluid having particles therein; (b) a particle separation member; (c) a first particle collector disposed below the particle separation member; and, (d) a particle transfer member positioned between the particle separation member and the particle collector whereby particles separated by the particle separation member are conveyed to the particle collector.

18. The separator of claim 17 wherein at least a portion of the particle transfer member is angled downwardly to the first particle collector whereby particles travel to the first particle collector at least partially under the influence of gravity.

19. The separator of claim 17 wherein the first particle separation member is chosen from the group of a cyclone, a Prandtl layer turbine and an electrostatic filter.

20. The separator of claim 17 further comprising a second particle separation member disposed upstream of the first particle separation member.

21. The separator of claim 20 further comprising a second particle collector positioned to receive particles separated by the second particle separation member and the first and second particle collectors are configured such that the first particle collector is emptied when the second particle collector is emptied.

22. The separator of claim 21 wherein the first particle collector is disposed above the second particle separation member.

23. The separator of claim 22 wherein the first particle collector is positioned in the second particle separation member.

24. The separator of claim 23 wherein the second particle collector is removably mounted in a casing and the first particle collector is constructed to empty into the second particle when the second particle collector is removed from the casing.

25. The separator of claim 21 wherein the first particle collector is disposed adjacent the second particle separation member.

26. The separator of claim 17 wherein the particle transfer member comprises a pivotally mounted disc.

27. A separator for separating entrained particles from a fluid flow, the separator comprising: (a) first separating means for separating particles from the fluid flow; (b) second separating means for separating particles from the fluid flow; (c) first particle collecting means for collecting particles separated from the fluid flow by the first separating means; (d) second particle collecting means for collecting particles separated from the fluid flow by the second separating means; and, (e) directing means for directing particles from the first particle separating means to the first particle collecting means.

28. The separator of claim 27 wherein at least a portion of the directing means is angled downwardly whereby particles travel to the first particle collecting means at least partially under the influence of gravity.

29. The separator of claim 28 wherein the second particle collecting means is positioned above the first

particle collecting means.

30. The separator of claim 29 wherein the first particle collecting means is removably mounted in a casing and the second particle collecting means empties into the first particle collecting means as the first particle collecting means is prepared for emptying.

31. The separator of claim 27 further comprising a cleaning head having a dirty air inlet and the separator is connectable in fluid flow communication with the dirty air inlet wherein the separator comprises the filtration stage of a vacuum cleaner.

32. A vacuum cleaner comprising a casing having at least two filtration stages whereby the filtration stages are configured so that dirt removed by each filtration is emptied at the same time.

33. The vacuum cleaner of claim 32 wherein the vacuum cleaner has a first filtration stage comprising a single cyclone and a second filtration stage comprising a plurality of cyclones.

34. The vacuum cleaner of claim 33 wherein the plurality of second stage cyclones are connected in parallel.

35. The vacuum cleaner of claim 34 wherein the plurality of second stage cyclones are positioned upstream from the single cyclone.

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Method and apparatus of particle transfer in multi-stage particle separators

Description of corresponding document: WO0195780

Title: METHOD AND APPARATUS OF PARTICLE TRANSFER IN MULTI-STAGE PARTICLE SEPARATORS FIELD OF THE INVENTION

The present invention relates generally to the transfer and removal of particles separated in multi-stage separators such as may be used by vacuum cleaners. In one particular application, the invention relates to the multi-stage separation having upstream and downstream separation stages wherein the position at which the separated particles exit from the downstream separation stage is positioned above the position at which the separated particles exit the upstream separation stage.

BACKGROUND OF THE INVENTION

The use of multiple cyclones connected in parallel or series has long been known to be advantageous in the separation of particulate matter from a fluid stream. Typically, a relatively high speed fluid stream is introduced tangentially to a generally cylindrical or frusto-conical first stage cyclone separator, wherein the dirty air stream is accelerated around the inner periphery of the first stage cyclone separator. Fluid exiting the first stage cyclone separator is fed to the inlet of a second stage cyclone separator wherein the described separation process is repeated. Typically, successive separators are configured to remove ever-smaller particles from the fluid stream, until a desired cleaning efficiency is achieved. Particulate matter disentrained from the fluid flow is typically collected at the bottom of each stage.

The advantages of multi-stage cyclonic separation are disclosed in U. S. Patent No. 3,425,192 to Davis. As shown in Figure 1, multi-stage separator 10 essentially comprises a large, lower first stage cyclone separator 12 connected in series with a plurality of smaller, parallel second stage cyclone separators 14 disposed over cyclone separator 12. A motor (not shown) draws air through a cleaning head and into a dirty air inlet 16 of the first stage cyclone separator 12. From first stage cyclone separator 12, the air flows into second stage cyclone separators 14 and, from there, continues on through the vacuum motor to a clean air exhaust port (not shown). Particles separated from the fluid flow are deposited by first stage cyclone separator 12 into a primary collector 20, while particles separated from the fluid flow by second stage cyclone separators 14 are deposited into a secondary collector 22, vertically disposed over primary collector 20. When primary and/or secondary collectors 20 and 22 become laden with deposited particles, and must therefore be emptied, two distinct emptying steps are required to clear the collectors of their contents.

SUMMARY OF THE INVENTION

In accordance with the instant invention, there is provided a vacuum cleaner comprising a cleaner head having a dirty air inlet; and, a casing having a filtration member, the filtration member having an inlet in fluid flow communication with the dirty air inlet and an outlet in fluid flow communication with a source of suction, the filtration member comprising at least one upstream particle separator having an associated upstream particle collector and at least one downstream particle separator having an associated downstream particle collector, the particle collectors are configured such that the downstream particle collector is emptied by transferring its contents into the upstream particle collector.

In one embodiment, at least a portion of the upstream particle separator is removable from the casing and the downstream particle collector is emptied into the upstream particle collector when the portion of the upstream particle collector is removed from the casing.

In another embodiment, the vacuum cleaner further comprises a particle transfer member positioned between one of the particle separation members and its associated particle collector whereby particles separated by the said particle separation member are conveyed to said particle collector.

In another embodiment, at least a portion of the particle transfer member is angled downwardly whereby particles travel to said particle collector at least partially under the influence of gravity.

In another embodiment, the downstream particle separation member is chosen from the group of a cyclone, a Prandtl layer turbine and an electrostatic filter.

In another embodiment, the downstream particle collector is positioned in the upstream particle separation member.

In another embodiment, the downstream particle collector is pivotally mounted above the upstream particle collector.

In another embodiment, the downstream particle collector has side walls and a bottom that is mounted for movement between a closed position and an open position and the bottom moves to the open position as the upstream particle collector is prepared for emptying.

In another embodiment, the bottom is maintained in the closed position by interaction between the bottom and a member positioned on a portion of the vacuum cleaner that is not removed with the upstream particle collector.

In another embodiment, the downstream particle collector is disposed adjacent the upstream particle separation member.

In accordance with another aspect of the instant invention, there is provided a separator for separating entrained particles from a fluid flow, the separator comprising a first particle separation member; a reusable particle collector disposed beneath the particle separation member, the particle collector having a moveable member movably mounted between a closed position and an open position; and, a particle receiving chamber disposed beneath the particle collector, wherein when the moveable member moves from its closed position to its open position, particles collected in the particle collector are substantially transferred to the particle receiving chamber.

In accordance with another aspect of the instant invention, there is provided a separator comprising an inlet in fluid flow communication with a source of fluid having particles therein; a particle separation member; a first particle collector disposed below the particle separation member; and, a particle transfer member positioned between the particle separation member and the particle collector whereby particles separated by the particle separation member are conveyed to the particle collector.

In accordance with another aspect of the instant invention, there is provided a separator for separating entrained particles from a fluid flow, the separator comprising first separating means for separating particles from the fluid flow; second separating means for separating particles from the fluid flow; first particle collecting means for collecting particles separated from the fluid flow by the first separating means; second particle collecting means for collecting particles separated from the fluid flow by the second separating means; and, directing means for directing particles from the first particle separating means to the first particle collecting means.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made by way of example to the accompanying drawings.

The drawings show a preferred embodiment of the present invention, in which:

Figure 1 is a vertical cross section through a multi-stage cyclonic separator according to the prior art;

Figure 2 is a perspective view of a multi-stage separator according to the present invention;

Figure 3a is an exploded perspective view of the multi-stage separator of Figure 2;

Figure 3b is an exploded perspective view of an alternate embodiment of the multi-stage separator of Figure 2;

Figure 4 is a perspective view of the multi-stage separator of

Figure 2, with the second stage collector shown in a partially open position;

Figure 5 is a perspective view of a household vacuum cleaner according to the present invention;

Figure 6 is a perspective view of an alternate embodiment of a multi-stage separator having a particle transfer member according to the present invention;

Figure 7 is a perspective view of a further alternate embodiment of a multi-stage separator having a particle transfer member according to the present invention ;

Figure 8 is a perspective view of a further alternate embodiment of a household vacuum cleaner having a particle transfer member according to the present invention;

Figure 9 is a perspective view of a further alternate embodiment of the second stage particle collector according to the present invention; and,

Figure 10 is an enlarged side view of the second stage particle collector of Figure 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to multi-stage particle separation systems wherein the particles separated in a second (or downstream) separation stage are transported to a position wherein they may be removed from the multi-stage particle separation systems together with the particles separated in a first (or upstream) separation stage. The improvements may be used in any multi-stage separation system wherein material separated by a second stage separation process is to be stored in a storage container which is to be periodically emptied. The downstream separation stage may use any separation technique, eg a cyclone separator, a Prandtl layer turbine, an electrostatic precipitator or the like, which produces separated particles that must be handled in such a way that they will not be re-entrained in fluid flowing through the downstream separation stage (eg, stored in a reusable container). Preferably, the downstream and the upstream separation stages use such separation techniques.

The preferred embodiment of the present invention is described in its use with a vacuum cleaner and in particular an upright vacuum cleaner. It will be appreciated that the improvements in multistage separation described herein may be used with canister vacuum cleaners, back pack vacuum cleaners, central vacuum cleaner systems as well as single and multi-stage separators of any sort, including industrial dust or particle collection systems wherein particles are to be removed from a fluid (i. e. a liquid and/or a gas).

An improved multi-stage separator according to the present invention is shown generally in the Figures at 30. Referring to Figure 2, separator 30 comprises a first stage cyclone 32 and a plurality of second stage cyclones 34. First stage cyclone 32 has a first stage collector 36 and second stage cyclones 34 have a second stage collector 38. First stage cyclone 32 and second stage cyclones 34 are housed within a housing 40 having a top 41, a lower portion comprising container 66 and an upper portion comprising second stage assembly 51. As shown in Figure 2, top 41 comprises a mesh screen that is positioned upstream of a motor driven fan. However, it will be appreciated that second stage assembly 51 may be open or it may be closed if it is provided with a fluid outlet. First stage cyclone 32 has an fluid inlet 42, fed by a fluid feed conduit 45, and a fluid outlet 46. Fluid outlet 46 feeds a transfer conduit 44 which is in fluid communication with a plurality of second stage cyclones 34 via a plurality of inlets 47. Second stage cyclones 34 each have a fluid outlet 49 positioned beneath mesh screen 41.

As shown in Figure 2, transfer conduit 44 extends above mesh screen 41 to engage a support member (not shown) to fix second stage cyclones 34 in position. The interior of conduit 44 is sealed to cause the air to enter second stage cyclones 43. Alternately, transfer conduit 44 may terminate at inlets 47 and alternate support means may be provided to position second stage cyclones 34 in second stage assembly 51 (eg. by means of support members attached to the inner wall of second stage assembly 51).

While the first and second stages are connected in series, it will be appreciated that the improvements disclosed herein may be used in a system wherein the first and second stages are connected in parallel. It will also be appreciated that additional separation stages may be positioned upstream, downstream or both upstream and downstream from the first and second separation stages. It will further be appreciated that first stage cyclone 32 may comprise a plurality of cyclones and/or that the second stage may comprise only one second stage cyclone 34 (see for example Figure 7). The fluid may be propelled through separator 30 by any means known in the art. For example, a pump may be positioned upstream of separator 30 or, in the case of a vacuum cleaner, a source of suction (eg. a motor driven fan) may be positioned downstream from separator 30.

Beneath second stage cyclones 34 is a particle transfer member 48 which slopes downwardly to second stage collector 38. Second stage collector 38 has side walls 50 and a bottom 52. Referring to Figure 3a, bottom 52 is separable from side walls 50.

In the embodiment wherein separator 30 is used in a vacuum cleaner (see, for example, Figure 5), a motor-driven fan draws particleladen fluid via a feed conduit into first stage inlet 42 via fluid feed conduit 45. The fluid flows cyclonically within a first stage cyclone 32 depositing particles in first stage collector 36 (which may be the bottom surface of container 66). The fluid exits first stage cyclone 32 via outlet 46 and is delivered by conduit 44 to the inlets 47 of second stage cyclones 34.

Cyclonic flow in second stage cyclones 34 further separates particles from the fluid flow, which particles fall on to particle transfer member 48 for transfer to second stage collector 38. The fluid flow then exits second stage cyclones 34 via outlets 49, and is expelled from separator 30. The separated particles travel